Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- SEMESTER–VII (NEW) EXAMINATION – WINTER 2024

Subject Code:3170511 Date:16-12-2024

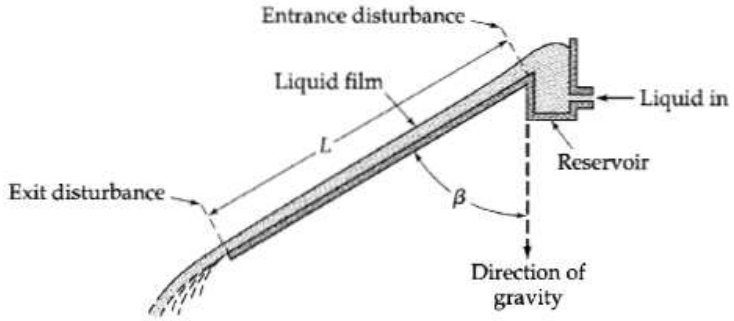
Subject Name: Transport Phenomena

Time:10:30 AM TO 01:00 PM Total Marks:70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

			Marks
Q.1	**(a)**	Differentiate between Cartesian, cylindrical and spherical coordinate systems.	**03**
	(b)	Write the expression for 1. Dot product of two vector **v** and **w**. 2. Cross product of two vector **v** and **w**. 3. Multiplication of a Tensor **τ** by a Scalar **s.** 4. Addition of vector **v** and **w**.	**04**
	(c)	For steady-state axial flow of an incompressible liquid in an annular region between two coaxial cylinders of radii kR and R, through annulus the velocity profile is given by $v_z = \frac{(\mathcal{P}_0 - \mathcal{P}_L)R^2}{4\mu L}\left[1 - \left(\frac{r}{R}\right)^2 - \frac{1-\kappa^2}{\ln(1/\kappa)}\ln\left(\frac{R}{r}\right)\right]$ Find the 1. The maximum velocity 2. The average velocity 3. The mass flow rate 4. The force exerted by the fluid on the solid surfaces.	**07**
Q.2	**(a)**	What is control volume? How the shape of control volume is decided?	**03**
	(b)	Write the equation for steady state shell energy balance. What are the most common boundary conditions used in shell energy balance?	**04**
	(c)	Develop the shear stress and velocity distribution profile for the laminar flow through the circular pipe. State assumptions made while deriving these expressions.	**07**
		OR	
	(c)	for the downward laminar flow through inclined plane for if shear stress profile is given as $\tau_{xz} = (\rho g \cos\beta).x$	**07**

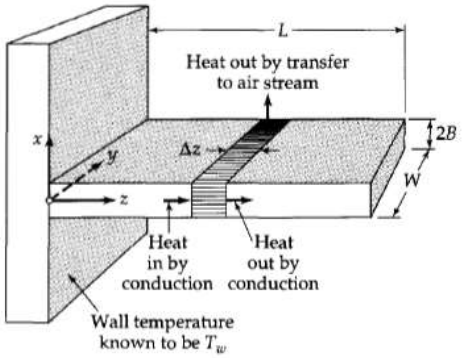


Develop the velocity distribution profile for Newtonian fluid.
If angle β is zero, what will be shear stress profile and velocity distribution?
State assumptions made while deriving these expressions.

Q.3 **(a)** Compare and contrast the molecular and convective mechanisms for heat transport. **03**

(b) The thermal conductivity of a sheet of rigid, extruded insulation is reported to be k = 0.029 W/m.K. The measured temperature difference across a 20-mm-thick sheet of the material is T1 -T2 = 10°C. **04**
(a) What is the heat flux through a 2 m * 2 m sheet of the insulation?
(b) What is the rate of heat transfer through the sheet of insulation?
Assumptions
(1) One-dimensional conduction in the x-direction
(2) Steady-state conditions
(3) Constant properties.

(c) Develop the heat flux and temperature distribution profile for heat conduction in a rectangular fin **07**
State assumptions made while deriving these expressions.



OR

Q.3 **(a)** Why is the thermal conductivity of a solid generally larger than that of a liquid? Why is the thermal conductivity of a liquid larger than that of a gas? **03**

(b) What is the physical significance of thermal diffusivity? How it is defined and what are its units? **04**

(c) Develop the heat flux and temperature distribution profile for heat conduction through electrical heat source. State assumptions made while deriving these expressions. **07**

Q.4 **(a)** Write in brief about Mass average and molar average velocity. **03**

(b) Compare the forced and free convection in non-isothermal systems with a suitable diagram. **04**

(c) Derive a suitable expression for steady-state diffusion of A through stagnant B with the liquid-vapor interface maintained at a fixed position. **07**

OR

Q.4 **(a)** Differentiate between Molecular mass flux and convective mass flux. **03**

(b) Write the common boundary conditions used in shell mass balance. **04**

(c) What is Fick's law of Diffusion? Discuss it with suitable diagram. **07**

Q.5 **(a)** Define the following **03**

1. Brinkman Number
2. Biot Number
3. Prandtl Number

(b) Define Thiele modulus. What is the significance of Thiele modulus? **04**

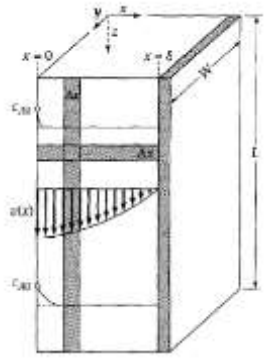
(c) For the given figure shows the absorption of gas A into falling liquid B, the velocity profile is presented by **07**

$$v_z(x) = v_{max}\left[1 - \left(\frac{x}{\delta}\right)^2\right]$$

Establish a mass balance on component A considering $C_A = f(x,z)$ and formulate the following differential equation:

$$v_{max}\left[1 - \left(\frac{x}{\delta}\right)^2\right]\frac{\partial c_A}{\partial z} = \mathcal{D}_{AB}\frac{\partial^2 c_A}{\partial x^2}$$

Assume:
Transport of A in the *z* direction will be primarily by convection.
In the x direction A moves predominantly by diffusion.

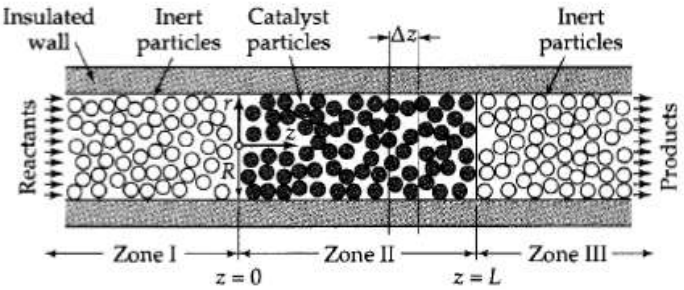


OR

Q.5 **(a)** How the equation of change differs in single component and multicomponent system? **03**

(b) Discuss in brief about diffusion with homogeneous catalytic reaction. **04**

(c) For the fixed-bed axial flow reactor shown in figure, find the steady state axial temperature distribution. The fluid is flowing axially in plug flow with superficial velocity v_0. **07**



The reactants enter at z = -∞ and leave at z = +∞. The reaction zone is from z = 0 to z = L.

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